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JEE

(Main)

PAPER-1 (B.E./B. TECH.)

2023

COMPUTER BASED TEST (CBT) Questions & Solutions

Date: 29 January, 2023 (SHIFT-2) | TIME : (3.00 p.m. to 6.00 p.m)

Duration: 3 Hours | Max. Marks: 300






SUBJECT: PHYSICS

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PART : PHYSICS

1. The electric current in a circular coil of four turns produces a magnetic induction 32 T at its centre. The coil is unwound and is rewound into a circular coil of single turn, the magnetic induction at the centre of the coil by the same current will be:

(1) 8 T (2) 2 T (3) 4 T (4) 16 T

Ans. (2)

Sol. $32 = \frac{4 \times \mu_0 I}{2 \frac{\ell}{8\pi}} \dots(1)$

$B = 1 \times \frac{\mu_0 I}{2 \times \frac{\ell}{2\pi}} \dots(2)$

From equation (1) & (2)

$$\frac{32}{B} = \frac{16}{1}$$

$$B = 2T$$

2. A square loop of area 25 cm² has a resistance of 10 Ω. The loop is placed in uniform magnetic field of magnitude 40.0 T. The plane of loop is perpendicular to the magnetic field. The work done in pulling the loop out of the magnetic field slowly and uniformly in 1.0 sec, will be

(1) 5 × 10⁻³ J (2) 1.0 × 10⁻⁴ J (3) 2.5 × 10⁻³ J (4) 1.0 × 10⁻³ J

Ans. (4)

Sol. $\ell^2 = 25 \text{ cm}^2$

$$\ell = 5$$

$$V = \frac{5}{0.1} = 50, F = Bi\ell$$

$$F = B \frac{B\ell v}{R} \ell = \frac{B^2 \ell^2 v}{R}$$

$$W = F\ell = \left(\frac{B^2 \ell^2 v}{R} \right) \ell = \frac{40^2 \times (.05 \times 0.05) \times 5 \times 0.05}{10} = \frac{40 \times 40 \times 625 \times 10^{-7}}{10} = 10^{-7}$$

3. Given below are two statements:

Statement I : Electromagnetic waves are not deflected by electric and magnetic field.

Statement II : The amplitude of electric field and the magnetic field in electromagnetic waves are related

to each other as $E_0 = \sqrt{\frac{\mu_0}{\epsilon_0}} B_0$.

In the light of the above statements, choose the correct answer from the options

- (1) Statement I is true but statement II is false (2) Statement I is false but statement II is true
(3) Both statement I and Statement II are true (4) Both statement I and Statement II are false

Ans. (1)






Sol. $C = \frac{E_0}{B_0} ; E_0 = B_0 C = \frac{B_0}{\sqrt{\mu_0 \epsilon_0}}$

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4. The ratio of de-Broglie wavelength of an a particle and a proton accelerated from rest by the same potential is $\frac{1}{\sqrt{m}}$, the value of m is

- (1) 4 (2) 16 (3) 2 (4) 8

Ans. (4)

Sol. $\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2mqv}}$

$$\lambda_{\alpha} = \frac{h}{\sqrt{2 \times 4m \times 2eV}}, \lambda_P = \frac{h}{\sqrt{2 \times m \times eV}}$$

$$\frac{\lambda_{\alpha}}{\lambda_P} = \frac{\frac{h}{\sqrt{2 \times 4m \times 2eV}}}{\frac{h}{\sqrt{2 \times m \times eV}}} = \frac{1}{2\sqrt{2}} = \frac{1}{\sqrt{8}} = \frac{1}{\sqrt{m}}$$

$$m = 8$$

5. A scientist is observing a bacteria through a compound microscope. For better analysis and to improve its resolving power he should. (Select the best option)

- (1) Decrease the focal length of the eye piece.
 (2) Increase the wave length of the light
 (3) Decrease the diameter of the objective lens
 (4) Increase the refractive index of the medium between the object and objective lens

Ans. (4)

Sol. Resolving power (R.P.) = $\frac{2\mu \sin \theta}{\lambda}$

If $\mu \uparrow \rightarrow$ R.P \uparrow ses
 RP $\propto \mu$

6. The equation of a circle is given by $x^2 + y^2 = a^2$, where a is the radius. If the equation is modified to change the origin other than (0, 0), then find out the correct dimensions of A and B in a new equation :

$$(a - At)^2 \left(y - \frac{1}{B} \right)^2 = a^2. \text{ The dimensions of t is given as } [T^{-1}].$$

- (1) A = [LT], B = [L⁻¹T⁻¹] (2) A = [L⁻¹T], B = [LT⁻¹]
 (3) A = [L⁻¹T⁻¹], B = [LT] (4) A = [L⁻¹T⁻¹], B = [LT⁻¹]

Ans. (1)

Sol. principle of homogeneity

Dimension of [x] = [A] [t]
 [L] = [A] [T⁻¹]
 [A] = [LT]

Dimension of [x] = Dimension of $\left[\frac{t}{B} \right]$

$$[B] = \frac{[t]}{[x]} = [L^{-1}T^{-1}]$$

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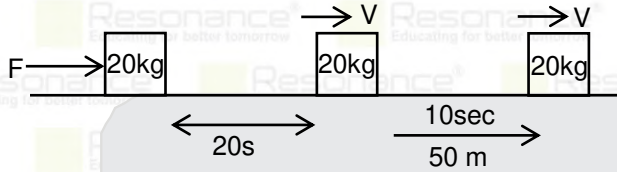
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7. A force acts for 20 s on a body of mass 20 kg, starting from rest, after which the force ceases and then body describes 50 m in the next 10 s. The value of force will be:

- (1) 40 N (2) 20 N (3) 5 N (4) 10 N

Ans. (3)

Sol. $F = 20 \times a$



$$V = \frac{50}{10} = 5$$

$$V = u + at$$

$$5 = 0 + a \times 20$$

$$a = 1/4, F = 20 \times 1/4 = 5 \text{ N}$$

8. With the help potentiometer, we can determine the value of emf of a given cell. The sensitivity of the potentiometer is

- (A) directly proportional to the length of the potentiometer wire
 (B) directly proportional to the potential gradient of the wire
 (C) inversely proportional to the potential gradient of the wire
 (D) inversely proportional to the length of the potentiometer wire

- (1) B and D only (2) A and C only (3) A only (4) C only

Ans. (2)

Sol. Sensitivity $\propto \frac{1}{\text{Potential gradient}}$

$$\propto \frac{1}{V/l} \Rightarrow \propto \frac{l}{V}$$

9. Heat energy of 184 kJ is given to ice of mass 600 g at -12°C . Specific heat of ice is $2222.3 \text{ J kg}^{-1} \text{ }^\circ \text{C}^{-1}$ and latent heat of ice is 336 kJ/kg^{-1}

- A. Final temperature of system will be 0°C .
 B. Final temperature of the system will be greater than 0°C .
 C. The final system will have a mixture of ice and water in the ratio of 5:1
 D. the final system will have a mixture of ice and water in the ratio of 1:5.
 E. The final system will have water only.

Choose the correct answer from the options given below:

- (1) A and D only (2) B and D only (3) A and E only (4) A and C only

Ans. (1)

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Sol. Heat required to convert ice or -12°C to ice of $0^{\circ}\text{C} = \frac{600 \times 2222.3 \times 12}{1000}$
 $= 1600 \text{ J} = 16 \text{ kJ}$
 Heat given = 184 kJ
 remaining heat = $184 - 16 = 168 \text{ kJ}$

$$\text{Amount of ice melt} = \frac{168 \text{ kJ}}{\text{Latent heat}} = \frac{168}{336} \text{ kg} = .5 \text{ kg}$$

$$\frac{\text{Amount of water}}{\text{Amount of ice}} = \frac{500}{100} = \frac{5}{1} \Rightarrow \frac{M_{\text{ice}}}{M_{\text{water}}} = \frac{1}{5}$$

10. An object moves at a constant speed along a circular path in a horizontal plane with centre at the origin. When the object is at $x = +2 \text{ m}$, its velocity is $-4\hat{j} \text{ m/s}$. The object's velocity (v) and acceleration (a) at $x = -2 \text{ m}$ will be

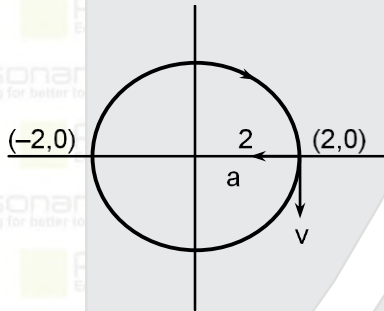
(1) $v = -4\hat{j} \text{ m/s}, a = -8\hat{j} \text{ m/s}^2$

(2) $v = 4\hat{i} \text{ m/s}, a = 8\hat{j} \text{ m/s}^2$

(3) $v = 4\hat{j} \text{ m/s}, a = 8\hat{i} \text{ m/s}^2$

(4) $v = -4\hat{j} \text{ m/s}, a = 8\hat{i} \text{ m/s}^2$

Ans. (3)
Sol.



At $(2, 0)$; $\vec{v} = -4\hat{j}$

At $(-2, 0)$; $\vec{v} = 4\hat{j}$

$$\vec{a} = \frac{v^2}{r} \hat{i} = \frac{4^2}{2} \hat{i} = 8\hat{i} \Rightarrow \vec{a} = -2\hat{i}$$

11. The time taken by an object to slide down 45° rough inclined plane is n times as it takes to slide down a perfectly smooth 45° incline plane. The coefficient of kinetic friction

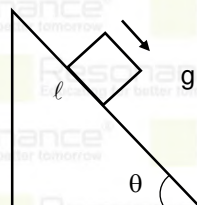
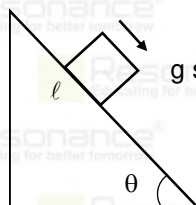
(1) $\sqrt{1 - \frac{1}{n^2}}$

(2) $\sqrt{\frac{1}{1 - n^2}}$

(3) $1 + \frac{1}{n^2}$

(4) $1 - \frac{1}{n^2}$

Ans. (4)
Sol.



$$l = \frac{1}{2} g \sin \theta t_1^2 = \frac{1}{2} g (\sin \theta - \mu \cos \theta) t_2^2$$

As $t_2 = n t_1$

$$1 = (1 - \mu) n^2 \Rightarrow \mu = 1 - 1/n^2$$

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12. Identify the correct statements from the following:

- A. Work done by a man in lifting a bucket out of a well by means of a rope tied to the bucket is negative.
- B. Work done by gravitational force in lifting a bucket out of a well by a rope tied to the bucket is negative.
- C. Work done by friction on a body sliding down an inclined plane is positive.
- D. Work done by an applied force on a body moving on a rough horizontal plane with uniform velocity is zero.
- E. Work done by the air resistance on an oscillating pendulum is negative.

Choose the correct answer from the options given below:

- (1) B, D and E only (2) A and C only (3) B and D only (4) B and E only

Ans. (4)

Sol. $W = FS \cos\theta$

13. A fully loaded boeing aircraft has a mass of 5.0×10^5 kg. Its total wing area is 500 m^2 . It is in level flight with a speed of 1080 km/h . If the density of air ρ is 1.2 kg m^{-3} , the fractional increase in the speed of the air on the upper surface of the wing relative to the lower surface in percentage will be. ($g = 10 \text{ m/s}^2$)

- (1) 16 (2) 8 (3) 10 (4) 6

Ans. (3)

Sol. $P_1 + \frac{1}{2}\rho v^2 = P_2 + \frac{1}{2}\rho(v + \Delta v)^2$

$$P_1 - P_2 + \frac{1}{2}\rho v^2 \left[\left(1 + \frac{\Delta v}{v}\right)^2 - 1 \right]$$

Lift force $(P_1 - P_2) A = mg$

$$\frac{1}{2}\rho v^2 \left[2\frac{\Delta v}{v} \right] A = mg ; \quad \frac{\Delta v}{v} = \frac{mg}{\rho v^2 A}$$

$$\frac{\Delta v}{v} \times 100 = \frac{mg}{\rho v^2 A} \times 100 = \frac{5.4 \times 10^5 \times 10}{1.2 \times (300)^2 \times 500} \% = 10\%$$

14. The time period of a satellite of earth is 24 hours. If the separation between the earth and the satellite is decreased to one fourth of the previous value, then its new time period will become.

- (1) 12 hours (2) 6 hours (3) 4 hours (4) 3 hours

Ans. (4)

Sol. $T^2 \propto R^3$

$$\Rightarrow \left(\frac{T_1}{T_2}\right)^2 = \left(\frac{R_1}{R_2}\right)^3 \Rightarrow T_2 = T_1 \times \left(\frac{R_2}{R_1}\right)^{3/2} = 24 \left(\frac{R_1}{4 \times R_1}\right)^{3/2}$$

$$T_2 = 24 \times \frac{1}{2^3} = 3\text{h}$$

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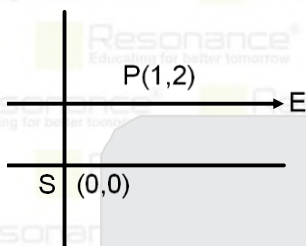
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15. A point charge 2×10^{-2} is moved from P to S in a uniform electric field of 30 NC^{-1} directed along positive x-axis. If coordinates of P and S are (1, 2, 0) m and (0, 0, 0) m respectively, the work done by electric field will be

(1) 600 mJ (2) -1200 mJ (3) -600 mJ (4) 1200 mJ

Ans. (3)

Sol.



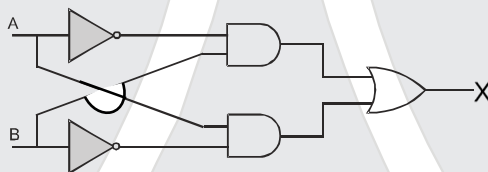
$$V_S > V_P$$

$$W_{\text{electric}} = q(V_S - V_P)$$

$$= -qES$$

$$= -2 \times 10^{-2} \times 30 \times 1 = -600 \text{ mJ}$$

16. For the given logic gates combination the correct truth table will be



(1)

A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

(2)

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

(3)

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

(4)

A	B	X
0	0	1
0	1	0
1	0	1
1	1	0

Ans. (1)

17. Substance A has atomic mass number 16 and half life of 1 day. Another substance B has atomic mass number 32 and half life of $\frac{1}{2}$ day. If both A and B simultaneously start undergo radio activity at the same

time with initial mass 320 g each, how many total atoms of A and B combined would be left after 2 days.

(1) 3.38×10^{24} (2) 6.76×10^{24} (3) 1.69×10^{24} (4) 6.76×10^{23}

Ans. (1)

Sol. $N_1 = \frac{320}{16} \times N_A = 20N_A$

$$N_2 = \frac{320}{32} \times N_A = 10N_A$$

$$N = N_1 e^{-\lambda_1 t} + N_2 e^{-\lambda_2 t}$$

$$= \frac{N_1}{4} + \frac{N_2}{16} = \frac{20N_A}{4} + \frac{10N_A}{16} = \frac{45}{8} \times N_A = \frac{45}{8} \times 6 \times 10^{23} = 3.38 \times 10^{24}$$

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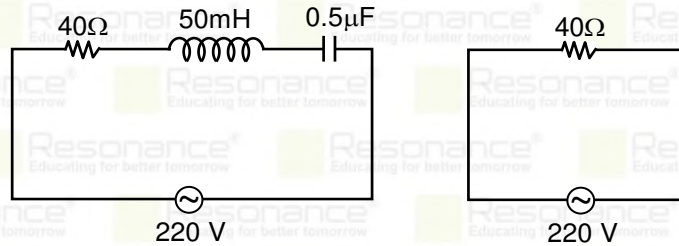
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18. For the given figure, choose the correct options:



- (1) The rms current in figure (a) is always equal to that in figure (b)
- (2) The rms current in circuit (b) can be larger than that in (a)
- (3) The rms current in circuit (b) can never be larger than that in (a)
- (4) At resonance, current in (b) be less than that in (a)

Ans. (3)

Sol. $Z_a = 40$

$$Z_b = \sqrt{40^2 + (X_L - X_C)^2}$$

$$Z_b \geq Z_a$$

$$I_b \leq I_a$$

19. The modulation index for an A.M. wave having maximum and minimum peak-to-peak voltages of 14 mV and 6 mV respectively is-

- (1) 0.6
- (2) 1.4
- (3) 0.4
- (4) 0.2

Ans. (3)

Sol.
$$\mu = \frac{A_{\max} - A_{\min}}{A_{\max} + A_{\min}} = \frac{14 - 6}{14 + 6}$$

$$= \frac{8}{20} = 0.4$$

20. At 300 K, the rms speed of oxygen molecules is $\sqrt{\frac{a+5}{a}}$ times to that of its average speed in the gas.

Then, the value of a will be (used $\pi = \frac{22}{7}$)

- (1) 27
- (2) 24
- (3) 32
- (4) 28

Ans. (4)

Sol.
$$V_{\text{rms}} = \sqrt{\frac{3RT}{m_0}}, \quad V_{\text{avg}} = \sqrt{\frac{8}{\pi} \cdot \frac{RT}{m_0}}$$

given

$$V_{\text{rms}} = \sqrt{\frac{a+5}{a}} V_{\text{avg}}$$

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$$\sqrt{\frac{3RT}{m_0}} = \sqrt{\frac{a+5}{a}} \times \sqrt{\frac{8}{\pi} \cdot \frac{RT}{m_0}}$$

$$3 = \frac{a+5}{a} \cdot \frac{8}{\pi}$$

$$3 = \frac{a+5}{a} \cdot \frac{8}{22}$$

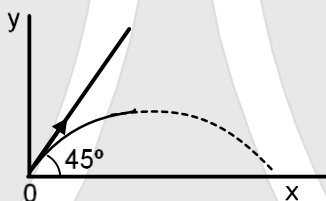
$$3 = \frac{a+5}{a} \times \frac{4 \times 7}{11}$$

$$3 = \frac{28(a+5)}{11a}$$

$$33a = 28a + 140$$

$$a = 28$$

21. A particle of mass 100 g is projected at time $t = 0$ with a speed 20 ms^{-1} at an angle 45° to the horizontal as given in the figure. The magnitude of the angular momentum of the particle about the starting point at time $t = 2\text{s}$ is found to be $\sqrt{K} \text{ kg m}^2/\text{s}$. The value of K is _____. (Take $g = 10 \text{ ms}^{-2}$)



Ans. 800

Sol. Torque of mg at time $t = (u_x) mg \times t$

$$= \frac{20}{\sqrt{2}} \times 0.1 \times 10t = \frac{20}{\sqrt{2}} t$$

$$L = \int \tau dt = \frac{20}{\sqrt{2}} = \sqrt{K}$$

$$k = \frac{1600}{2} = 800$$

22. An inductor of inductance $2 \mu\text{H}$ is connected in series with a resistance, a variable capacitor and an AC source of frequency 7 kHz . the value of capacitance for which maximum current is drawn into the circuit is $\frac{1}{x} \text{ F}$, where the value of x is _____. (Take $\pi = \frac{22}{7}$)

Ans. 3872

Sol. $X_L = X_C$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$LC = \frac{1}{4\pi^2 f^2}$$

$$C = \frac{1}{4\pi^2 f^2 L} = \frac{1}{x}$$

$$x = 4\pi^2 f^2 L$$

$$= 4 \times \pi^2 \times 49 \times 10^6 \times 2 \times 10^{-6} = 392 \pi^2 = 392 \times \frac{22 \times 22}{49} = 3872$$

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23. A null point is found at 200 cm in potentiometer when cell in secondary circuit is shunted by 5Ω . When a resistance of 15Ω is used for shunting, null point moves to 300 cm. the internal resistance of the cell is $___\Omega$.

Ans. 5

Sol. $r = \left[\frac{l_1}{200} - 1 \right] 5 = \left[\frac{l_1}{300} - 1 \right] 15$

$$r = l_1 = 400 \left(\frac{400}{200} - 1 \right) 5 = 5 \Omega$$

24. In an experiment of measuring the refractive index of a glass slab using travelling microscope in physics lab, a student measures real thickness of the glass slab as 5.25 mm and apparent thickness of the glass slab as 5.00 mm. Travelling microscope has 20 divisions in one cm on main scale and 50 divisions on vernier scale is equal to 49 divisions on main scale. The estimated uncertainty in the measurement of refractive index of the slab is $\frac{x}{10} \times 10^{-3}$, where is x _____

Ans. 41

Sol. 20 MSD = 10 mm

1 MSD = 0.5 mm

50 VSD = 49 MSD

1 VSD = $\frac{49}{50} \times 0.5 \text{ mm}$

LC = 1 MSD - 1 VSD

LC = $0.5 \text{ mm} - \frac{49}{50} \times 0.5 \text{ mm} = 0.01 \text{ mm} = \Delta h$

$n = \frac{h_{\text{actual}}}{h_{\text{apparent}}} = \frac{5.25}{5} = 1.05$

$\left(\frac{dn}{n} \right)_{\text{max}} = \frac{dh_{\text{actual}}}{h_{\text{actual}}} + \frac{dh_{\text{apparent}}}{h_{\text{apparent}}} = \frac{.01}{5.25} + \frac{0.01}{5}$

$\frac{\Delta n_{\text{max}}}{1.05} = 0.01 \times \left(\frac{1}{5.25} + \frac{1}{5} \right) = \frac{41}{10} \times 10^{-3}$






x = 41

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25. A car is moving on a circular path of radius 600 m such that the magnitudes of the tangential acceleration and centripetal acceleration are equal. The time taken by the car to complete first quarter of revolution, if it is moving with an initial speed of 54 km/hr is $t(1 - e^{-x/2})$ s. The value of t is _____.

Ans. 40

Sol.

$$|a_c| = |a_t|$$

$$\frac{v^2}{R} = \frac{dv}{dt}$$

$$\int_{v_0}^v \frac{dv}{v^2} = \frac{1}{R} \int_0^t dt$$

$$\frac{1}{v_0} - \frac{1}{v} = \frac{t}{R}$$

$$\frac{1}{v} = \frac{1}{v_0} - \frac{t}{R} \Rightarrow v = \frac{v_0 R}{R - v_0 t}$$

$$\frac{ds}{dt} = \frac{v_0 R}{R - v_0 t}$$

$$\int_0^{\pi R/2} dS = v_0 R \int_0^t \frac{dt}{R - v_0 t}$$

$$\frac{\pi R}{2} = \frac{v_0 R}{-v_0} \ln \left(\frac{R - v_0 t}{R - 0} \right)$$

$$\frac{\pi}{2} = \ln \left(\frac{R}{R - v_0 t} \right)$$

$$\frac{R}{R - v_0 t} = e^{\pi/2} \Rightarrow R e^{-\pi/2} = R - v_0 t$$

$$t = \frac{R}{v_0} \left(1 - e^{-\pi/2} \right) = \frac{600}{15} \times \left(1 - e^{-\pi/2} \right) = 40 \times \left(1 - e^{-\pi/2} \right)$$

26. A particle of mass 250 g executes a simple harmonic motion under a periodic force $F = (-25x)$ N. The particle attains a maximum speed of 4 m/s during its oscillation. The amplitude of the motion is _____ cm.

Ans. 40

Sol. $K = 25, \quad \omega = \sqrt{\frac{25}{0.25}} = 10 \text{ rad/sec}$

$$V_{\max} = A\omega$$

$$4 = A \times 10$$

$$A = 0.4 \text{ m} = 40 \text{ cm}$$

27. For a charged spherical ball, electrostatic potential inside the ball varies with r as $V = 2ar^2 + b$. Here, a and b are constant and r is the distance from the centre. The volume charge density inside the ball is $-\lambda a \epsilon$. The value of λ is _____ $\epsilon =$ permittivity of the medium

Ans. 12

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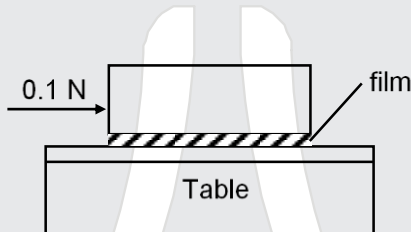
Sol. $E = - \frac{dU}{dr} = 4ar$

$$E \cdot 4\pi r^2 = \frac{q_{in}}{\epsilon_0}$$

$$\frac{3\epsilon_0 \times E}{r} = \rho$$

$$\frac{3\epsilon_0 \times 4ar}{r} = 12\epsilon_0 a$$

28. A metal block of base area 0.20 m^2 is placed on a table, as shown in figure. A liquid film of thickness 0.25 mm is inserted between the block and the table. The block is pushed by a horizontal force of 0.1 N and moves with a constant speed. If the viscosity of the liquid is $5.0 \times 10^{-3} \text{ Pa}\cdot\text{s}$, the speed of block is $\underline{\hspace{2cm}} \times 10^{-3} \text{ m/s}$



Ans. 25

Sol. $V = \frac{FD}{A\eta} = 25 \times 10^{-3} \text{ m/sec}$

29. Unpolarised light is incident on the boundary between two dielectric media whose dielectric constants are 2.8 (medium-1) and 6.8 (medium-2), respectively. To satisfy the condition, so that the reflected and refracted rays are perpendicular to each other, the angle of incidence should be $\tan^{-1}\left(1 + \frac{10}{\theta}\right)^{\frac{1}{2}}$ the value of θ is $\underline{\hspace{2cm}}$. (Given for dielectric media, $\mu_r = 1$)

Ans. 7

Sol. $\sqrt{\frac{6.8}{2.8}} = \tan\left(1 + \frac{10}{\theta}\right)^{\frac{1}{2}}$

$$\frac{68}{28} = 1 + \frac{10}{\theta} \Rightarrow \theta = \frac{28}{4} = 7$$

30. When two resistance R_1 and R_2 connected in series and introduced into the left gap of a meter bridge and a resistance of 10Ω is introduced into the right gap, a null point is found at 60 cm from left side. When R_1 and R_2 are connected in parallel and introduced into the left gap, a resistance of 3Ω is introduced into the right-gap to get null point at 40 cm from left end. The product of $R_1 R_2$ is $\underline{\hspace{2cm}} \Omega^2$

Ans. 30

Sol. $\frac{R_1 + R_2}{10} = \frac{60}{40}$;

$$\frac{R_1 \times R_2}{R_1 + R_2} = \frac{40}{3} = \frac{60}{60}$$

$$\frac{R_1 R_2}{3(R_1 + R_2)} = \frac{10}{R_1 + R_2} \Rightarrow R_1 R_2 = 30$$

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